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Office workers' objectively assessed total and prolonged sitting time: Individual-level correlates and worksite variations

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Sedentary behavior is highly prevalent in office-based workplaces; however, few studies have assessed the attributes associated with this health risk factor in the workplace setting. This study aimed to identify the correlates of office workers' objectively-assessed total and prolonged (≥30 min bouts) workplace sitting time. Participants were 231 Australian office workers recruited from 14 sites of a single government employer in 2012–13. Potential socio-demographic, work-related, health-related and cognitive-social correlates were measured through a self-administered survey and anthropometric measurements. Associations with total and prolonged workplace sitting time (measured with the activPAL3) were tested using linear mixed models. Worksites varied significantly in total workplace sitting time (overall mean [SD]: 79% [10%] of work hours) and prolonged workplace sitting time (42% [19%]), after adjusting for socio-demographic and work-related characteristics. Organisational tenure of 3–5 years (compared to tenure >5 years) was associated with more time spent in total and prolonged workplace sitting time, while having a BMI categorised as obese (compared to a healthy BMI) was associated with less time spent in total and prolonged workplace sitting time. Significant variations in sitting time were observed across different worksites of the same employer and the variation remained after adjusting for individual-level factors. Only BMI and organisational tenure were identified as correlates of total and prolonged workplace sitting time. Additional studies are needed to confirm the present findings across diverse organisations and occupations.

1. Introduction

Exposure to high levels of workplace sedentary (sitting) time has become common, particularly in office environments (Healy et al., 2012). Office-based workers have been reported to spend between two-thirds and three-quarters of their working hours sitting (Thorp et al., 2012; Parry and Straker, 2013; Clemes et al., 2014; Ryan et al., 2011), with a high proportion accrued in prolonged, unbroken bouts of 30 min or more (Parry and Straker, 2013; Ryan et al., 2011). Consistent evidence has linked high levels of sitting with chronic diseases and premature mortality (Biswas et al., 2015; de Rezende et al., 2014) and prolonged sitting with cardio-metabolic risk (Healy et al., 2008). Thus, exposure to excessive workplace sitting is an emerging workplace health and safety issue (Straker et al., 2014).

Despite a growing interest in workplace interventions (Neuhaus et al., 2014a), relatively little is known about factors influencing workplace sitting time; knowledge which could improve targeting of

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strategies. While factors relating to work have been identified as potential correlates (Hadgraft et al., 2015; Mummery et al., 2005; Wallmann-Sperlich et al., 2014; De Cocker et al., 2014), only two studies (Wallmann-Sperlich et al., 2014; De Cocker et al., 2014) have assessed cognitive-social factors that may influence sitting time. Both studies noted the need for confirmatory and additional research (Wallmann-Sperlich et al., 2014; De Cocker et al., 2014). Also, no previous studies have analysed potential correlates of prolonged sitting time (i.e. unbroken bouts) to assess whether these attributes differ from those associated with total workplace sitting time.

Existing studies have also used self-report questionnaires to measure sitting time (Hadgraft et al., 2015; Wallmann-Sperlich et al., 2014; De Cocker et al., 2014). Relative to self-report, objective-measurement devices—such as inclinometers—can determine the volumes and accumulation patterns of sitting time with better validity and accuracy (Clark et al., 2011). The use of objective-measures of workplace sitting in studies assessing correlates reduces the potential for measurement error.

The factors influencing workplace sitting are likely to operate at multiple levels – including individual, cognitive-social, environmental, and policy levels (Owen et al., 2011). The extent to which workplace sitting is influenced by factors acting at the individual-level, compared with at the organisational-level, is of interest when considering how interventions should be designed and targeted. This may include whether strategies should be individually-driven and targeted at "high risk" groups and/or aimed at influencing the organisational-level through policy and cultural change. Assessing the variation in sitting time between worksites, before and after accounting for individual-level factors, provides the opportunity to explore such issues.

The aim of this study was to examine the worksite-level variation, and the socio-demographic, health-related, work-related, and cognitive-social correlates of objectively-assessed total and prolonged workplace sitting time in Australian office-based workers. Given limited evidence relating to the correlates of workplace sitting time, including prolonged workplace sitting, this study employed an exploratory, data-driven approach.

2. Methods

2.1. Study design and participants

Participants were recruited for a cluster randomized controlled trial of a multi-component workplace intervention aimed at reducing workplace sitting (the Stand Up Victoria [SUV] trial). They were informed that the study aimed to "investigate the effectiveness of an intervention to increase overall physical activity levels at the workplace". The intervention, detailed elsewhere (Dunstan et al., 2013; Neuhaus et al., 2014b; Healy et al., 2016), comprised organisational-, environmental- (sit-stand workstation), and individual-level strategies. Here, we report findings derived from baseline measurements. In brief, recruitment and randomization occurred at the worksite-level. Fourteen geographically separate worksites were recruited from a single government department (Victoria, Australia). At each site, a work team (i.e., a distinct group with dedicated team leader(s) and regular group meetings) was selected (if team size was <10, two teams were combined). Eligibility criteria included: aged 18–65 years, English-speaking, worked ≥0.6 full time equivalent (FTE) and had designated access to a telephone, internet, and desk within the workplace. Participants did not have height-adjustable desks at baseline. Participants' roles mostly involved telephone-based and clerical/administrative tasks.

Of the 278 who originally expressed interest, 33 were ineligible and 14 were no longer eligible and/or willing to participate at the intervention commencement, leaving 231 participants. Ethics approval was granted by Alfred Health Human Ethics Committee (Melbourne, Australia). The SUV trial was prospectively registered with the Australian New Zealand Clinical Trials Registry (ACTRN12611000742976).

2.2. Data collection

At baseline, trained staff conducted onsite assessments to collect anthropometric measurements, provide participants with activity monitors and logbooks, and give instructions on activity monitor use (see below). Thereafter, participants completed a self-administered online questionnaire (LimeService), containing questions relating to socio-demographic, work, health-related and cognitive-social characteristics.

2.3. Measures

2.3.1. Objectively measured sitting time and moderate-vigorous physical activity (MVPA)

Sitting time was measured objectively using the activPAL3 activity monitor (PAL Technologies Limited, Glasgow, UK) which provides highly accurate measures of sitting time and sitting accumulation (Lyden et al., 2012). Participants were asked to wear the activPAL for seven consecutive days (24 h/day) following the onsite assessment. The monitor was waterproofed and secured to the anterior mid-line of the right thigh, about one third down from the hip, using hypoallergenic adhesive material. During waking hours (apart from water-based activities) participants also wore the tri-axial Actigraph GT3X+ activity monitor (ActiGraph, Pensacola, Florida) on an elastic belt over their right hip. Participants were asked to record sleep and waking times, work hours and any device removals >15 min in a logbook.

Activity monitor data were processed in SAS 9.3 (SAS Institute Inc., Cary NC), with reference to participant logbooks. Quality controls were conducted before (e.g. diary entry errors) and after processing (visual checking). For activPAL data, events were coded as: awake, non-wear, or at work when they were mostly (≥50%) within these periods. Non-wear time and sleep were excluded. Workplace time was taken as all work hours for this employer from any location. Days were considered valid for workplace time when the device was worn for ≥80% of work hours (see Edwardson et al., 2016 for details of compliance). Times spent sitting, sitting for ≥30 min continuously (prolonged sitting), standing and stepping during work hours were averaged from the totals for valid days and standardised to an 8-h day. Time, rather than the number of prolonged bouts, was used as the outcome as it provides a more informative measure of the extent or duration of exposure to this potential health risk.

The GT3X+ data (extracted as 60-s epochs) were used to identify MVPA(Harrington et al., 2011) based on all minutes with ≥1952 vertical acceleration counts (Freedson et al., 1998) on valid days (≥10 h waking wear time). The activPAL estimation of MVPA, using a cadence-based equation, does not have high agreement with referent methods (Harrington et al., 2011). Non-wear time (≥60 min of 0 counts, allowing for up to 2 min with 1–49 counts) (Winkler et al., 2012) was excluded, as was sleep (McVeigh et al., 2015). Non-work time excluded work for any employer, and days the participant reported working but did not indicate work times. Non-work MVPA (min/day) was calculated using a weighted daily average (average non-work day MVPA × 2/7 + non-work time MVPA on work days × 5/7) to account for differences in non-work time on such days and the number of work and non-work days during the monitoring period.

2.3.2. Socio-demographic and health-related variables

Participants reported their age, gender, ethnicity (Caucasian; Asian; other), marital status (married/de facto; separated/divorced/widowed; never married), educational attainment (high school or lower; trade/vocational; university level) and smoking status at work (yes; no). Non-work MVPA was calculated as above. Body mass index (BMI) was calculated from height, measured using a portable stadiometer (average of two measures; third if the difference was ≥0.5 cm), and mass, measured to the nearest 0.1 kg using bioelectrical impedance analysis scales. BMI was categorised as underweight (BMI < 18.5 kg/m^2), healthy (18.5 − <25 kg/m^2), overweight (25 − <30 kg/m^2) and obese (≥30 kg/m^2). Given only one underweight participant, the underweight and healthy weight categories were combined.

2.3.3. Work-related variables

Individual-level work-related variables included: a measure of working hours – 1.0 FTE (yes; no), tenure at the current workplace (<3 years; 3–5 years; >5 years), and occupational skill level (managers; professionals/associate professionals; clerical/sales/services workers).

2.3.4. Cognitive-social variables

Six cognitive-social constructs were assessed: workspace satisfaction (average of four items); knowledge (five items); barrier self-efficacy (nine items); perceived behavioral control (five items); perceived organisational social norms (eight items); and, frequency of use of self-regulation strategies (10 items). These were adapted from physical activity literature or developed for the trial to be specific to workplace sitting (Dunstan et al., 2013), for example, barrier self-efficacy related to barriers to reducing workplace sitting; perceived organisational social norms related to norms about workplace sitting/standing. Items were measured on 1–5 Likert scales (strongly disagree–strongly agree; not at all confident–very confident; never–very often). Item questions and construct internal consistency are provided in Supplementary Table 1. Cronbach's alpha coefficients ranged from 0.50 (knowledge) to 0.92 (barrier self-efficacy). Two items from the Health Work Questionnaire (Shikiar et al., 2003) assessed job control (*How much control did you feel you had over how you did your job this week*?) and overall stress (*Overall, how stressed have you felt this week*?) on 10-point scales (1 = no control, 10 = total control; 1 = not stressed at all, 10 = very stressed). Participants also self-reported their desired proportion of the day spent sitting at work (categorised as <50%; ≥50%).

2.4. Statistical analyses

Descriptive statistics were calculated for the whole sample and by worksite. To assess the correlates of total and prolonged sitting time (min/8-h workday), linear mixed models were used, with worksite cluster specified as a random effect. Models were limited to participants with complete data for outcomes and covariates (n = 214). Potential correlates were entered in three blocks: (i) socio-demographic and health-related variables; (ii) work-related variables; and (iii) cognitive-social variables. As this study was exploratory in nature, the final adjusted models were obtained using backwards elimination. All potential correlates were forced into the model and variables with the highest p-value removed one-by-one until only those with $p < 0.20$ remained (Faraway, 2002). Age and gender were retained in all models. Likelihood ratio tests were used to assess goodness of fit after variable removal and Akaike's Information Criterion and Bayesian Information Criterion were calculated to compare models. Retained variables from previous blocks were included for successive blocks. Variance Inflation Factors (VIFs) were <2.5 in all models. The minimum difference of interest for total and prolonged sitting time was 45 min (Dunstan et al., 2013).

To assess worksite variation in the outcome variables, the random intercept for worksite was tested by likelihood ratio test. The difference between each worksite-specific mean and the overall mean was estimated using Best Linear Unbiased Predictions. Worksite variation was considered unadjusted, and correcting for compositional effects (i.e., individual attributes not pertaining to work).

Data were analysed in Stata 12.1 (StataCorp LP, College Station, TX); $p < 0.05$ was considered statistically significant.

3. Results

3.1. Participant characteristics

Participant characteristics are presented in Table 1. The majority (69%) were women and 67% were aged 35–55 years, which was broadly typical of all departmental employees (72% women; 59% aged 35-< 55 years) (Department of Human Services, 2014). Most were Caucasian, worked in clerical/administrative roles and had tenures >5 years. The sites were varied in their composition, for example, the proportion university qualified ranged from 14% (site G) to 75% (site D).

On average, approximately four-fifths of working hours were spent sitting, with 42% spent in prolonged sitting bouts. Comparatively less time was spent standing and stepping (Table 2). Sitting time was proportionately higher on work days than non-work days.

3.2. Correlates of total workplace sitting time

In terms of socio-demographic and health-related variables (Block 1), marital status and BMI category were significant correlates of total workplace sitting time, while work smoking status, ethnicity, non-work MVPA and education dropped out of the model (see Table 3). Of the work-related variables (Block 2) only tenure was significantly associated with total workplace sitting. No cognitive-social variables (Block 3) were significantly correlated, with all factors other than knowledge and use of self-regulation strategies dropping out. Adjustment for cognitive-social variables did not significantly alter effect sizes, although the overall test for marital status became non-significant (p = 0.07). In the fully adjusted model, participants with an obese BMI averaged 21 min (per 8-h workday) less workplace sitting time (ref: healthy BMI). Tenure of 3–5 years was associated with an average 23 min additional workplace sitting time (ref: >5 years). Participants who were separated, divorced or widowed spent on average 15 min less time sitting (ref: married/de facto). Neither age, nor gender was significant correlates.

The significant variation between sites remained evident across each model. In the final model, the ICC was 0.144 (95% CI: 0.042, 0.388), indicating that 14% of workplace sitting variation was explained by worksite differences (although the margin of error was wide). Fig. 1 shows the worksite variation in total workplace sitting time. Unadjusted, the site average was 378 min/8-h workday (95% CI: 368, 389 min). Worksites varied from 21 min below (worksite A) to 22 min above average (worksite N). After adjusting for socio-demographic and health-related variables, worksites varied from 21 min below (worksite B) through to 27 min above (worksite N) the average (388 min/8-h workday, 95% CI: 357, 418 min).

3.3. Correlates of workplace sitting time accumulated in prolonged bouts

Table 4 shows the correlates of workplace sitting time accumulated in prolonged bouts. BMI category was the only significant Block 1 variable. In Block 2, the only significant correlate was tenure, although occupational category remained in the model. None of the cognitive-social variables (Block 3) were significantly associated with prolonged sitting, although perceived behavioral control and perceived organisational norms remained in the model. The addition of these cognitive-social variables did not attenuate associations of BMI and tenure with prolonged sitting time. Participants who were overweight or obese averaged 50 and 40 min/8-h workday respectively, less prolonged sitting time (ref: healthy BMI). Tenure of 3–5 years was associated with an average 50 min/8-h workday additional prolonged workplace sitting (ref: >5 years). The non-significant variables remaining in the model were estimated with a wide margin of error but indicated potentially large differences in prolonged sitting time (e.g. nearly 1 h difference between professionals/associate professionals and managers).

Table 1
Descriptive characteristics of worksites.

Worksite	A	B	C	D	E	F	G	H	I	J	K	L	M	N	Total
Site/team attributes															
Site size*	M	S	M	L	L	L	M	L	M	M	L	M	S	M	
Number in team (s)**	14	30	21	50	180*	150*	25	60	22	74	166*	48	22	18	
n (enrolled)	12	5	13	9	38	17	7	24	11	35	18	25	9	8	231
Predominately phone-based?	No	No	No	No	Yes	Yes	No	Yes	No	Mixed	Mixed	Yes	Mixed	No	
Individual attributes															
n (complete demographics)	12	5	13	8	36	17	7	22	11	35	18	25	9	8	226
Socio-demographic															
Female	10 (83)	3 (60)	7 (54)	3	26 (72)	14 (82)	6 (86)	16 (73)	8 (73)	19 (54)	11 (61)	17 (68)	8 (89)	7 (88)	155 (69)
Age	49.3 ± 7.9	49.3 ± 7.7	48.0 ± 8.2	42.5 ± 13.3	48.3 ± 9.3	43.1 ± 9.6	44.0 ± 8.6	41.6 ± 9.5	51.8 ± 8.1	45.9 ± 9.0	40.9 ± 8.2	44.6 ± 9.3	44.0 ± 9.7	46.6 ± 10.5	45.5 ± 9.4
Marital status															
Married/de facto	6 (50)	4 (80)	11 (85)	4 (50)	26 (72)	10 (59)	6 (86)	14 (64)	7 (64)	22 (63)	11 (61)	16 (64)	6 (67)	5 (63)	148 (65)
Ethnicity															
Caucasian	9 (75)	3 (60)	10 (77)	8 (100)	23 (64)	17 (100)	6 (86)	20 (91)	9 (82)	30 (86)	16 (89)	18 (72)	6 (67)	5 (63)	180 (80)
Education															
High school or less	5 (42)	2 (40)	4	0 (0)	18	4	2	5	2	14 (40)	6	7	3	3	75
Trade/vocational	3	0 (0)	5	2	7	10 (59)	4 (57)	7	3	5	7	7	3	0 (0)	63
University level	4	3 (60)	4	6 (75)	11	3)	1	10 (45)	6 (55)	16 (46)	5	11 (44)	3	5 (63)	88
Health-related															
BMI (kg/m^2)															
Healthy (<25 kg/m^2)	4	1	2	2	12	5	0 (0)	11 (50)	4	11)	3	6)	4 (44)	2	67
Overweight (25 − <30 kg/m^2)	2	3 (60)	7 (54)	3	13)	5	4 (57)	8	2	13	6	10 (40)	2	2	80
Obese (≥30 kg/m^2)	6 (50)	1	4	3	11	7 (41)	3 (43)	3	5 (45)	11	9 (50)	9	3	4 (50)	79
Smokes at work	1	1	0 (0)	1	7)	0 (0)	0 (0)	3	1	5	4	6	0 (0)	2	31
Non-work MVPA (average min/day)***	17 ± 12	25 ± 21	25 ± 21	41 ± 18	17 ± 12	36 ± 18	20 ± 17	28 ± 20	18 ± 14	22 ± 17	21 ± 14	19 ± 15	22 ± 22	13 ± 8	23 ± 17
Work-related															
1.0 FTE	11 (92)	3 (60)	7 (54)	8 (100)	29 (81)	11 (65)	6 (86)	17 (77)	9 (82)	28 (80)	15 (83)	22 (88)	7 (78)	6 (75)	179 (79)
Occupational category															
Managers	1	2 (40)	0 (0)	2	5	1	0 (0)	3	0 (0)	1	1	0 (0)	0 (0)	0 (0)	16
Professional/Assoc. Professional	1	0 (0)	0 (0)	5 (63)	4	1	0 (0)	6	1	5	1	5	1	1	31
Clerical, sales & services	10 (83)	3 (60)	13 (100)	1	27 (75)	15 (88)	7 (100)	13 (59)	10 (91)	29 (83)	16 (89)	20 (80)	8 (89)	7 (88)	179 (79)
Tenure at workplace															
3 years	2	0 (0)	1	2	2	1 (0)	1	0 (0)	0 (0)	11	3	4	1	0 (0)	28
3–5 years	0 (0)	0 (0)	1	0 (0)	5	3	1)	5	1	2	5	4	1	1	29
>5 years	10 (83)	5 (100)	11 (85)	6 (75)	29 (81)	13 (76)	5 (71)	17 (77)	10 (91)	22 (63)	10 (56)	17 (68)	7 (78)	7 (88)	169 (75)

Notes: Descriptive characteristics are reported as n (%) for categorical variables and mean ± standard deviation for continuous variables. * Site size: S (Small) - <50; M (Medium) – 50–150; L (Large): >150, ** Team numbers are approximate; *** n = 223. Data were collected in Victoria, Australia in 2012–13.

Table 2
Description of participants' percentage of time spent in various activities as measured by the activPAL3[a].

	Workplace (n = 229)	Workdays (n = 229)	Non-workdays (n = 227)	Overall (n = 229)
Sitting (%)	78.8 ± 9.5	69.4 ± 8.0	55.9 ± 13.0	64.6 ± 8.4
Prolonged sitting (≥30 min bouts) (%)	42.1 ± 19.4	35.7 ± 12.9	27.7 ± 14.8	32.9 ± 11.5
Standing (%)	14.3 ± 8.2	21.0 ± 6.4	31.0 ± 10.4	24.6 ± 6.8
Stepping (%)	6.9 ± 2.9	9.6 ± 3.1	13.1 ± 4.5	10.8 ± 3.1

[a] Data are mean ± standard deviation with linearized variance estimation. Percentages are calculated as a proportion of waking monitor wear time.

Worksites varied significantly in average prolonged workplace sitting time, even in the full adjusted model. Fig. 2 depicts the worksite variation in prolonged sitting time, unadjusted and after adjustment for socio-demographic and health characteristics. Around a mean of 197 (95% CI: 173, 220) min/8-h workday of prolonged sitting time, sites varied from 44 min below (Site B) to 57 min above average (Site N). After adjustment, sites varied from 49 min below (Site B) to 62 min above (Site N) the overall mean (200 min/8-h workday; 95% CI: 135, 265).

4. Discussion

To our knowledge, this study is the first to examine correlates of workplace sitting time (total and in prolonged bouts) using high-quality objective measurement. Shorter occupational tenures were associated with higher levels of total and prolonged workplace sitting, while excess BMI was associated with lower levels of total and prolonged workplace sitting.

This sample of office-based workers engaged in high amounts of workplace sitting on average, with wide variation between individuals and worksites. On average, 79% of working hours were spent sitting; more than half of which was prolonged sitting (≥30 min bouts). These findings are consistent with other studies within office environments (Parry and Straker, 2013; Clemes et al., 2014; Healy et al., 2013) and highlight the need for interventions in these settings.

None of the socio-demographic factors emerged as significant correlates of workplace sitting. Previous studies with population-based samples have reported other socio-demographic factors such as younger age (De Cocker et al., 2014; Bennie et al., 2015) and higher educational attainment (Wallmann-Sperlich et al., 2014; De Cocker et al., 2014) to be associated with higher self-reported workplace sitting. The homogeneity of our sample—involving a single employer and industry—may have limited the ability to test these associations.

BMI emerged as a significant inverse correlate of total and prolonged workplace sitting, contrary to previous studies (De Cocker et al., 2014; Chau et al., 2012; Levine et al., 2005). Higher BMIs have been associated with increased prevalence of work-related musculoskeletal disorders (da Costa and Vieira, 2010; Schmier et al., 2006). Participants with greater adiposity may possibly experience more physical discomfort in traditional seated arrangements, which could be alleviated by more frequent breaks (Thorp et al., 2014). However, we cannot rule out possible bias and measurement error. The knowledge of having activity

Table 3
Linear mixed models examining correlates of total workplace sitting time (min/8-h day).

	Empty model	Block 1[a]	Block 2[b]	Block 3[c]
		b (95% CI)	b (95% CI)	b (95% CI)
Intercept	378.49 (368.36, 388.63)	387.67 (357.21, 418.14)	380.76 (349.88, 411.65)	360.20 (310.30, 410.10)
Socio-demographic and health-related				
Age (years)		0.10 (−0.51, 0.72)	0.34 (−0.28, 0.96)	0.33 (−0.29, 0.94)
Gender				
Male (ref: female)		7.33 (−4.68, 19.34)	8.99 (−3.09, 21.07)	8.06 (−4.04, 20.15)
Marital status		*p = 0.035*†	*p = 0.055*†	*p = 0.067*†
Married/de facto		Ref	Ref	Ref
Separated/divorced/widowed		−16.76 (−32.00, −1.51)*	−15.90 (−30.90, −0.89)*	−15.24 (−30.17, −0.31)*
Never married		−13.43 (−28.25, 1.38)	−11.58 (−26.18, 3.03)	−11.21 (−25.74, 3.33)
BMI		*p = 0.014*†	*p = 0.007*†	*p = 0.010*†
Healthy (<25 kg/m^2)		Ref	Ref	Ref
Overweight (25 − <30 kg/m^2)		−9.44 (−23.22, 4.35)	−11.86 (−25.50, 1.78)	−10.86 (−24.51, 2.79)
Obese (≥30 kg/m^2)		−20.54 (−34.42, −6.67)**	−22.06 (−35.73, −8.39)**	−21.05 (−34.70, −7.39)**
Work-related				
1.0 FTE (ref: <1.0)			−9.95 (−23.76, 3.86)	−9.38 (−23.20, 4.44)
Tenure at workplace			*p = 0.012*†	*p = 0.008*†
<3 years			16.72 (0.24, 33.20)*	15.45 (−0.97, 31.88)
3–5 years			20.31 (4.14, 36.49)*	22.59 (6.37, 38.82)**
>5 years			Ref	
Cognitive-social				
Knowledge				8.07 (−2.55, 18.69)
Use of self-regulation strategies				−5.76 (−13.26, 1.75)
Random effects‡				
Worksite (p-value)	p < 0.01	p < 0.01	p < 0.01	p < 0.01
Variance: worksite (between worksites)	236.37 (62.36, 895.84)	288.82 (85.76, 972.69)	279.25 (81.89, 952.23)	246.73 (68.25, 891.93)
Variance: residual (within worksite)	1696.10 (1391.67, 2067.12)	1563.13 (1282.61, 1905.01)	1489.08 (1221.54, 1815.20)	1471.79 (1207.10, 1794.51)
ICC	0.122 (0.034, 0.355)	0.156 (0.050, 0.394)	0.158 (0.050, 0.400)	0.144 (0.042, 0.388)
AIC	2219.56	2216.70	2212.46	2212.89
BIC	2229.66	2247.00	2252.85	2260.01
P vs previous block		p = 0.021	p = 0.017	p = 0.168

n = 214; * p < 0.05; ** p < 0.01; † *p* represents overall significance test for variable, ‡ Worksite specified as a random effect.
Note: ICC – Intracluster correlation coefficient; AIC – Akaike's Information Criterion; BIC – Bayesian Information Criterion. Data were collected in Victoria, Australia in 2012–13.
[a] Work smoking status, ethnicity, non-work MVPA, education eliminated.
[b] Occupational category eliminated.
[c] Workspace satisfaction, job control, barrier self-efficacy, desired sitting level, perceived behavioral control, perceived organisational norms, overall stress eliminated.

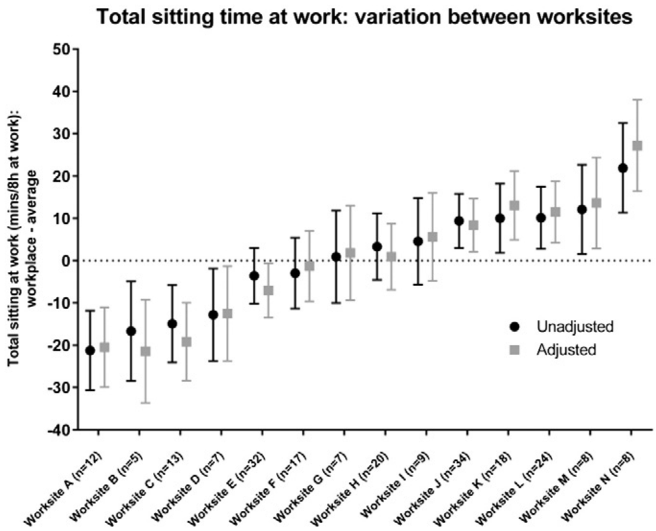

Fig. 1. Variation in total sitting time between worksites.

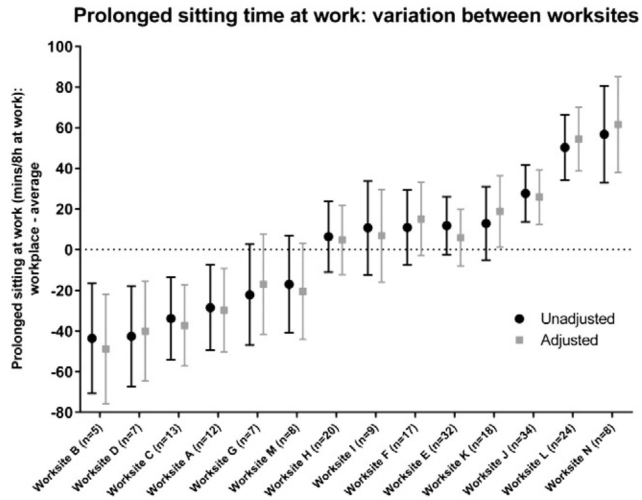

Fig. 2. Variation in prolonged sitting time between worksites.

monitored could have altered behavior differentially in our sample. Another possible explanation concerns the validity of the activPAL. While the activPAL appears to perform similarly for obese and healthy weight participants when assessing walking (Ryan et al., 2006), this has not been established for sitting and standing (delineated by estimated monitor angles, assumed to indicate thigh angle). Differential measurement error could arise if overweight/obesity affects thigh shape in a way relevant to device function, or how participants sit. Perching forward, in particular, can register as standing (Steeves et al., 2015).

Of the work-related factors, tenure greater than five years was associated with less total and prolonged workplace sitting time. Previous

Table 4
Linear mixed models examining correlates of prolonged workplace sitting time (min/8-h day).

	Empty model	Block 1[a]	Block 2[b]	Block 3[c]
	b (95% CI)	b (95% CI)	b (95% CI)	b (95% CI)
Intercept	196.6 (172.96, 220.24)	200.08 (134.77, 265.40)	216.87 (138.57, 295.16)	184.43 (68.93, 299.94)
Socio-demographic and health-related				
Age (years)		0.66 (−0.65, 1.97)	0.86 (−0.44, 2.17)	0.83 (−0.46, 2.12)
Gender				
Male (ref: female)		16.86 (−8.72, 42.44)	17.35 (−7.89, 42.59)	17.09 (−7.91, 42.10)
Marital status		*p = 0.100*†	*p = 0.104*†	*p = 0.198*†
Married/de facto		Ref	Ref	Ref
Separated/divorced/widowed		−23.09 (−55.58, 9.39)	−22.05 (−53.87, 9.78)	−19.41 (−51.22, 12.41)
Never married		−29.63 (−61.18, 1.93)	−28.76 (−59.60, 2.09)	−24.01 (−54.95, 6.94)
BMI		*p = 0.007*†	*p = 0.002*†	*p = 0.002*†
Healthy (<25 kg/m^2)		Ref	Ref	Ref
Overweight (25 − <30 kg/m^2)		−44.66 (−74.03, −15.29)**	−50.90 (−79.81, −21.98)**	−50.00 (−78.71, −21.29)**
Obese (≥30 kg/m^2)		−37.44 (−66.99, −7.89)*	−40.48 (−69.47, −11.48)**	−40.12 (−68.96, −11.28)**
Work-related				
Occupational category			*p = 0.142*†	*p = 0.148*†
Managers			Ref	Ref
Professionals/Assoc. Professionals			−53.92 (−107.58, −0.26)*	−53.50 (−107.17, 0.16)
Clerical, sales & services			−32.76 (−78.09, 12.58)	−33.84 (−79.63, 11.95)
Tenure at current workplace			*p = 0.005*†	*p = 0.008*†
<3 years			31.06 (−3.97, 66.09)	31.49 (−3.36, 66.33)
3–5 years			53.01 (18.04, 87.98)**	49.92 (15.12, 84.71)**
>5 years			Ref	Ref
Cognitive-social				
Perceived behavioral control				−15.71 (−34.30, 2.87)
Perceived organisational norms				22.93 (−3.48, 49.34)
Random effects‡				
Worksite (p-value)	p < 0.001	p < 0.001	p < 0.001	p < 0.001
Variance: worksite (between worksites)	1402.79 (430.77, 4568.13)	1498.77(485.61, 4625.70)	1473.84 (474.87, 4574.33)	1539.73 (503.76, 4706.16)
Variance: residual (within worksite)	7667.92 (6294.98, 9340.29)	7080.30 (5813.05, 8623.83)	6676.80 (5480.36, 8134.45)	6547.51 (5374.00, 7977.29)
ICC	0.155 (0.051, 0.383)	0.175 (0.062, 0.404)	0.181 (0.064, 0.416)	0.190 (0.069, 0.428)
AIC	2544.94	2541.32	2537.18	2537.65
BIC	2555.04	2571.61	2580.94	2588.14
P vs previous block		p = 0.016	p = 0.016	p = 0.171

n = 214; * p < 0.05; ** p < 0.01; † *p* represents overall significance test for variable, ‡ Worksite specified as a random effect.
Note: ICC – Intracluster correlation coefficient; AIC – Akaike's Information Criterion; BIC – Bayesian Information Criterion. Data were collected in Victoria, Australia in 2012–13.
[a] Education, non-work moderate-vigorous physical activity, ethnicity, work smoking status eliminated.
[b] Employment status eliminated.
[c] Use of self-regulation strategies, desired sitting level, overall stress, job control, workspace satisfaction, barrier self-efficacy, knowledge eliminated.

research has found tenures of at least five years to be associated with higher self-reported sitting (Vandelanotte et al., 2013). It is possible that tenure acts indirectly through other factors such as seniority; workers with longer tenure may have responsibilities requiring greater movement around the office. However, only 7% reported their occupation as managerial. The underlying mechanisms behind this finding should be explored further.

The effect sizes for BMI and tenure for prolonged sitting time were large, meeting the minimum difference of interest set for the broader intervention trial (45 min of total/prolonged sitting) (Dunstan et al., 2013). Effect sizes for total sitting time were more modest—approximately 15–30 min—although these differences were seen in the absence of any workplace intervention.

None of the cognitive-social constructs emerged as significant correlates. Similar cognitive-social constructs assessed previously (Wallmann-Sperlich et al., 2014; De Cocker et al., 2014) were also not found to be strong influences on workplace sitting. Nonetheless, with the observed margins of error our study did not provide evidence to rule out the importance of these factors. There were indications of a potential positive association between prolonged sitting time and perceived organisational norms and a potential negative association between prolonged sitting time with perceived behavioral control; the latter finding is in line with some previous studies (De Cocker et al., 2014; Prapavessis et al., 2015).

We observed large and significant differences between worksites in total and prolonged workplace sitting time, in unadjusted and adjusted models. Anecdotally, the level of task variation differed between sites—the teams with lower than average sitting time (sites A-D) were not predominately telephone-based, unlike others (e.g. H and L) that had higher sitting levels. More detailed assessment of job tasks or content (i.e. beyond assessing occupation) should be considered in future studies. Further exploration is needed to identify potential worksite-level factors influencing sitting that were not measured in our study.

An ecological model of sedentary behavior (Owen et al., 2011) suggests that there are multiple levels of influence on behavior. A significant limitation is that the variables assessed as potential correlates—and thus, our findings—reflect a data-driven approach. Not all of these potential influences were captured and others that were not assessed may also be of importance. In addition, while the cognitive-social constructs had theoretical relevance to the logic of the intervention, we did not aim to comprehensively test a single theory. The newly developed measures may also be affected by measurement error. This could account for the large proportion of unexplained variance in workplace sitting. Future studies should assess the potential influence of variables such as physical environments, organisational and social factors on total and prolonged sitting as these may be amenable to workplace environmental and policy changes.

Participants were government employees with mostly administrative and telephone-based customer service roles and were not randomly sampled. Our findings may not be generalizable to all office-based workers or organisations. However, we found limited evidence to suggest that participants were atypical, with high participation rates within most teams, and participants broadly similar to the departmental gender and age profile. While the broader intervention trial was powered to assess changes in the primary outcome, wide estimates of error suggest this study was underpowered and meaningful associations were possibly not detected. Studies that investigate the correlates of objectively measured sitting across larger, more diverse groups of workers are required to address these issues.

5. Conclusions

In this sample of office-based workers, shorter tenure and lower BMI levels were associated with higher levels of total and prolonged workplace sitting time, while significant variation in sitting time was observed across worksites. This suggests that identifying and assessing potential workplace-level correlates, such as physical environment and social-cultural factors, may be a useful next step in the research agenda for understanding and influencing workplace sitting. Overall, while these findings contribute to the existing limited evidence base on correlates of workplace sitting, replication and confirmation of our findings is needed.

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.pmedr.2016.06.011.

Conflict of interest statement

The funding bodies had no influence on the conduct nor the findings of the study. No financial disclosures were reported by the authors of this paper, and the authors declare that there are no conflicts of interest.

Authors' contributions

DD, GH, EE, NO, AL, MM conceived the Stand Up Victoria (SUV) trial. GH, NO, EE, AL, MM, GW, LW, and DD participated in the design and coordination of the methodology and measurement tools for the SUV trial. NH, GH, NO, BL, EW & DD contributed to the conception and design of the study. NH analysed and interpreted the data and drafted the manuscript. EW and PS provided assistance with statistical analyses and interpretation. All authors were involved in manuscript development and critical review for important intellectual content. All authors read and approved the final manuscript.

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